

Instruction Manual



TR 503 Tracking Generator

070-3526-00

This document supports product serial numbers B010100 and above.

Warning

The servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to the Safety Summary prior to performing service.

Please check for change information at the rear of this manual.

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TABLE OF CONTENTS

	Page
LIST OF ILLUSTRATIONS	iii
OPERATORS SAFETY SUMMARY	iv
SERVICING SAFETY SUMMARY	v

Section 1 GENERAL INFORMATION AND SPECIFICATIONS

Introduction	1-1
Overview	1-1
Standards	1-2
Electrical Characteristics	1-2
Environmental Characteristics	1-3
Physical Characteristics	1-3
Accessories	1-3

Section 2 OPERATING INSTRUCTIONS

Introduction	2-1
About the Tracking Generator	2-1
Installation	2-1
Repackaging	2-1
Functions of the Controls and Connectors	2-1
Operators Checkout Procedure	2-2
Check Flatness	2-3
Check Output Level	2-4
Tracking Adjustment	2-4
Measuring Frequency	2-4

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

Section 3 THEORY OF OPERATION

General Description	3-1
Block Diagram Description	3-3
Detailed Circuit Description	3-3
RF and Microwave Circuits	3-3

Section 3 THEORY OF OPERATION (cont)

Bias and Leveling Loop Circuitry ..	3-3
Phase Lock Loop	3-4
Power Supply Regulators	3-5

Section 4 CALIBRATION

Introduction	4-1
History Information	4-1
Equipment Required	4-1
PERFORMANCE CHECK	4-2
Introduction	4-2
Preliminary Inspection	4-2
Performance Verification	4-2
Check Frequency Range	4-2
Check Output Level	4-2
Check Flatness	4-2
Check Auxiliary Output Level	4-3
Check for Spurious Signals	4-3
ADJUSTMENT PROCEDURE	4-4
Introduction	4-4
Complete or Partial Calibration	4-4
Test Points	4-4
Preliminary Preparation	4-4
55 MHz Oscillator Mode Adjust ...	4-4
Adjust the Normalizing Attenuator .	4-5
Output Level Calibration	4-6

Section 5 MAINTENANCE

Introduction	5-1
Static-Sensitive Components	5-1
Preventive Maintenance	5-1
Cleaning	5-2
Exterior	5-2
Interior	5-2
Lubrication	5-2
Visual Inspection	5-2
Transistor and Integrated Circuit Checks	5-2
Performance Checks and Recalibration	5-2
Troubleshooting	5-2

TABLE OF CONTENTS (cont)

Section 5 MAINTENANCE (cont)	Page
Troubleshooting Aids	5-2
Diagrams	5-2
Circuit Board Illustrations	5-3
Wiring Color Code	5-3
Multiple Terminal (Harmonica) Connectors	5-3
Resistor Values	5-3
Capacitor Marking	5-3
Diode Color Code	5-4
Transistor and Integrated Circuit Pin Configuration	5-4
Diode Checks	5-4
General Troubleshooting Technique	5-5
Corrective Maintenance	5-6
Obtaining Replacement Parts	5-6
Parts Repair and Replacement Program	5-6
Soldering Technique	5-6
Replacing the Square Pin for the Multi-pin Connectors	5-6
Selected Components	5-6

Section 5 MAINTENANCE (cont)	Page
Replacing Assemblies	5-7
Removing or Replacing Semi-rigid Coaxial Cables	5-7
Replacement of Microwave Assemblies	5-7
Separating the TR 503	5-7
Removing the Assembly	5-7
Replacing the 2.182 GHz Four Cavity Filter/Mixer Assembly	5-8
Remove and Replace the Filter Assembly	5-8
Filter Alignment Procedure	5-8

Section 6 REPLACEABLE ELECTRICAL PARTS

Section 7 DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Section 8 REPLACEABLE MECHANICAL PARTS

CHANGE INFORMATION

WARRANTY

Tektronix warrants that this product will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If any such product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, with shipping charges prepaid. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; or c) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

THIS WARRANTY IS GIVEN BY TEKTRONIX WITH RESPECT TO THIS PRODUCT IN LIEU OF ANY OTHER WARRANTIES, EXPRESSED OR IMPLIED. TEKTRONIX AND ITS VENDORS DISCLAIM ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. TEKTRONIX' RESPONSIBILITY TO REPAIR OR REPLACE DEFECTIVE PRODUCTS IS THE SOLE AND EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER FOR BREACH OF THIS WARRANTY. TEKTRONIX AND ITS VENDORS WILL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IRRESPECTIVE OF WHETHER TEKTRONIX OR THE VENDOR HAS ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES.

LIST OF ILLUSTRATIONS

Fig. No.		Page
2-1	Plug-in module installation	2-2
2-2	TR 503/492 System with frequency counter	2-3
3-1	TR 503/492 System diagram	3-2
4-1	Setup for performance check	4-3
4-2	Setup for adjustment procedure	4-5
4-3	Location of receptacle K, W520, and C524	4-5
4-4	Location of adjustment R215 and adjustments R225, R220, and R222.	4-6
5-1	Multipin (harmonica) connector configuration.	5-3
5-2	Color code for tantalum capacitors	5-3
5-3	Diode polarity markings	5-4
5-4	Pin configuration for semiconductor components	5-5
5-5	Procedure for separating two sections of the TR 503	5-7
5-6	Typical position for the mixer in the 2.182 GHz filter assembly	5-8
5-7	TR 503/492 System diagram showing phase-lock assembly	5-9
5-8	Positioning the TR 503 to adjust the 2.182 GHz filter/mixer assembly	5-10
5-9	Location of P446 on the mother board	5-11
5-10	Typical responses of the filter/mixer assemblies	5-11

OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary.

Terms In This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

Terms As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

Symbols In This Manual



This symbol indicates where applicable cautionary or other information is to be found.

Symbols As Marked on Equipment



DANGER — High voltage.



Protective ground (earth) terminal.



ATTENTION — refer to manual.

Power Source

The mainframe is intended to operate from a power source that does not apply more than 250 volts rms between the

supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

This mainframe is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Danger Arising From Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

Do Not Remove Covers or Panels

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.

Do Not Operate Without Covers (for TM 500 plug-ins only)

To avoid personal injury, do not operate this product without covers or panels installed. Do not apply power to the plug-in via a plug-in extender.

SERVICING SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY

Refer also to the preceding Operators Safety Summary.

Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

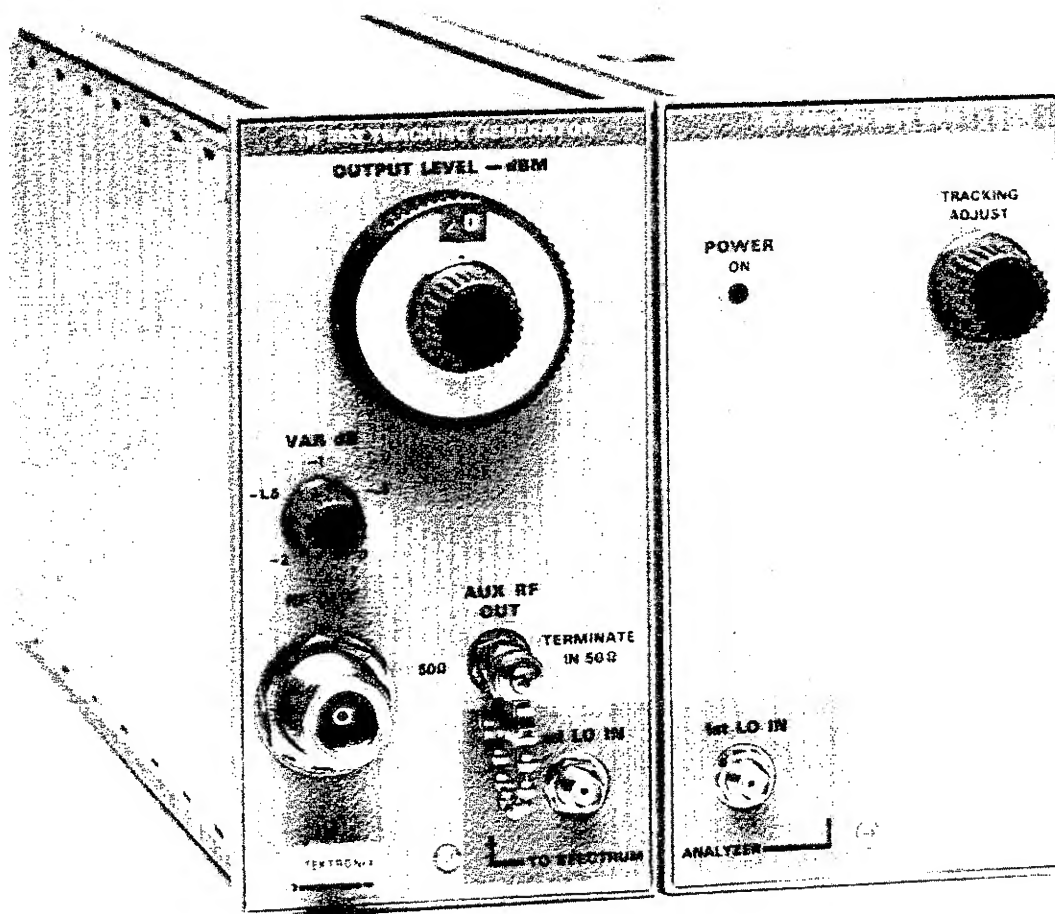
Use Care When Servicing With Power On

Dangerous voltages exist at several points in this product. To avoid personal injury, do not touch exposed connections and components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

Power Source

The mainframe is intended to operate from a power source that does not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.



3526-1

TR 503 Tracking Generator

GENERAL INFORMATION AND SPECIFICATIONS

Introduction

The TR 503 may be used to measure the frequency response of a device or component over a 100 kHz to 1.8 GHz range. It is used in conjunction with a TM 500 mainframe and a 492 Spectrum Analyzer. The tracking generator/spectrum analyzer method of response measurement has intrinsically greater rejection of device or environmental noise than the alternate swept sine-wave method.

The greater noise rejection is gained by having the 492 Spectrum Analyzer track the TR 503 output. Noise rejection is improved as the Resolution Bandwidth of the 492 is decreased; this is due to the 492 being immune to noise outside of the VR (Variable Resolution IF) bandwidth.

The TR 503 uses the 1st and 2nd LO (local oscillator) outputs of the 492 to generate a frequency that tracks the input of the 492. The TRACKING ADJUST control of the TR 503 allows fine adjustment of this frequency.

Points on the 492 display may have their frequencies measured by adding a frequency counter, such as the DC 508, to the TR 503/492 system. Measurements may be made directly from an external rf spectrum or obtained from the response curve of a device under test.

Overview

The Operators part of the manual is intended to help the user obtain maximum performance from the TR 503/492 system. This part covers General Information and the Operating Instructions.

The Service part of the manual covers the Theory of Operation, the Calibration section, and other service information, including the block and schematic diagrams of the TR 503.

The eight sections of the manual are:

Operators

Section 1—General Information and Specifications; contains the instrument description, a list of accessories, and a listing of the TR 503 Characteristics and Performance Requirements.

Section 2—Operating Instructions; introduces the user to the TR 503/492 system and demonstrates a series of measurement procedures.

Service

Section 3—Theory of Operation; describes all major circuits of the TR 503.

Section 4—Calibration, Part 1: Performance Check; this subsection is used to verify all of the Performance Requirements in the Specification, and to determine the need for recalibration (adjustment) of the TR 503.

Section 4—Calibration, Part 2: Adjustment Procedure; this subsection is used to return the TR 503 to conformance with the Performance Requirements. The procedure is arranged in functional blocks to facilitate referencing from the Performance Check and the Maintenance Instructions.

Section 5—Maintenance Instructions; describes routine and corrective maintenance procedures with detailed instructions for replacing assemblies, sub-assemblies, and individual components. An exploded drawing is part of Section 8.

Section 6—Replaceable Electrical Parts; provides information necessary to order replaceable parts and assemblies related to the electrical functions of the instrument.

Section 7—Diagrams; provides functional block diagram and circuit schematics. Pictorial layout drawings which show subassembly and component locations are adjacent to the diagram (usually on the back of the preceding diagram). Voltage and signal levels are included to aid in troubleshooting.

Section 8—Replaceable Mechanical Parts; provides information necessary in order to replace mechanical parts. This list is cross-referenced to the replaceable electrical parts list where appropriate. The Exploded Drawing shows the assembly sequence and identifies the assemblies. The Accessories page lists the standard and optional accessories.

Changes and Corrections; provides updating information for the manual in the form of inserts. These inserts are incorporated into the manual text and diagrams when the manual is updated.

Standards

The abbreviations and graphic symbols used in the text and diagrams of this manual are based on ANSI Y1.1-1972, ANSI Y32.2-1970, and ANSI Y32.14-1973 (American National Standards Institute, 345 East 47 Street, New York, N.Y. 10017).

SPECIFICATIONS

The following specifications apply to the TR 503 Tracking Generator and the TR 503/492 Spectrum Analyzer system. Allow at least 30 minutes warmup unless noted otherwise.

Items listed in the Performance Requirements column are verified by completing the Performance Check in Section 4 of this manual. Items listed in the Supplemental Information column may not be verified in this manual; they are either explanatory notes or performance characteristics for which no limits are specified.

Table 1-1

ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
Frequency Range	The TR 503 tracks the 492 tuned input frequency from 100 kHz to 1.8 GHz.	
Output Level		
Maximum Output	0 dBm \pm 0.5 dB	
Adjustment Steps	0 to 9 in 1 dB steps. 0 to 50 dB in 10 dB steps.	An additional 2 dB attenuation is provided by the front panel VAR dB control.
Attenuator Error	\pm 0.3 dB for each 1 dB change. Total error over the 59 dB range is \pm 1 dB.	
Output Impedance		50 Ω nominal, VSWR is 2:1 or less to 1.8 GHz.
Flatness		
TR 503	\pm 0.75 dB from 100 kHz to 1.8 GHz about midpoint (mean) between the two extremes.	
TR 503/492 System	\pm 2.25 dB from 100 kHz to 1.8 GHz, referred to 100 MHz.	
Dynamic Range		
TR 503/492 System		\geq 110 dB
Residual FM (peak-to-peak)		
TR 503		\leq 1 Hz
TR 503/492 System		\leq 10 Hz or same as 492, whichever is greater.

Table 1-1 (cont)

Characteristic	Performance Requirement	Supplemental Information
Auxiliary Output Level	0.1 V rms minimum, into a 50 Ω load.	
Spurious Signals (100 kHz—1.8 GHz)		
Harmonic	−20 dB or better with respect to the fundamental.	
Non-Harmonic	−40 dB or better with respect to the fundamental.	

Table 1-2

ENVIRONMENTAL CHARACTERISTICS

Characteristic	Description
Temperature Range	
Operating	0 to +50° C.
Non-Operating	−40 to +75° C.
Altitude Range	
Operating	To 15,000 feet.
Non-Operating	To 50,000 feet.

Table 1-3

PHYSICAL CHARACTERISTICS

Characteristic	Description
Finish	Anodized aluminum panel and chassis. Front panel faced with matt plastic.
Net Weight	8 lbs (3.64 kg)
Overall Dimensions	5.28 in (134.1 mm) H X 12 in. (304.8 mm) D X 4.96 in (126 mm) H.

STANDARD ACCESSORIES

Refer to tabbed pullout sheet at the end of the Replaceable Mechanical Parts section.

OPERATING INSTRUCTIONS

Introduction

This section describes the functions of the TR 503/492 system, the installation procedure, the controls and connectors, and the checkout procedure.

About the Tracking Generator

The TR 503 Tracking Generator is a two-wide instrument that plugs into a TM 500 mainframe. It provides the 492 Spectrum Analyzer with a level-calibrated RF signal source that tracks the input frequency of the analyzer from 100 kHz to 1.8 GHz. The output of the TR 503 is adjustable from 0 to -59 dBm in 1 dB steps. The TR 503/492 system can be used to display the frequency response of various devices such as filters, amplifiers, two-way transmission lines, etc., by connecting the devices between the TR 503 output and the 492 input.

If the 492 has Digital Storage, it is possible to conveniently measure frequencies appearing on the screen of the 492 by using a DC 508A with option 07 Frequency Counter connected to the AUX RF OUTPUT of the TR 503. These three instruments may be used to check frequencies appearing in RF spectra as well as making closed-loop response measurements.

Installation

The TR 503 was inspected both mechanically and electrically before shipment. It should be free of marks or scratches and electrically meet or exceed all specifications. To confirm this, inspect the instrument for physical damage incurred in transit and test the electrical performance by following the Operators Checkout Procedure in this section. If there is a problem, contact your local Tektronix Field Office or representative.

Install the TR 503 by aligning its guide rails with the tracks of mainframe compartment and then pushing the TR 503 into the compartment until the instrument's front panel is flush with the front panel of the mainframe. To remove the TR 503, pull the release latch on the lower left front panel. Refer to Fig. 2-1.

Repackaging

Save and re-use the TR 503 shipping container. If the original container is not available or damaged, repack the TR 503 as follows:

1. Attach a tag to the TR 503 that shows: name and address of firm, name of person responsible for the TR 503, serial number, and a description of the service required.

2. Obtain a shipping container made of heavy corrugated cardboard or wood. To allow for cushioning, make sure that the inside dimensions are no less than 12 by 12 by 18 inches (300 by 300 by 450 mm). This container should have a carton test strength of no less than 275 pounds (605 kg).

3. To protect the finish of the TR 503, wrap it in heavy paper or polyethylene. Protect the front panel with urethane foam or strips of cardboard.

4. Cushion the TR 503 by tightly packing urethane foam or dunnage between the TR 503 and the shipping container. Allow at least 3 inches on all sides.

5. Seal the container with shipping tape or an industrial stapler.

If there are any questions, contact the nearest Tektronix Field Office or representative.

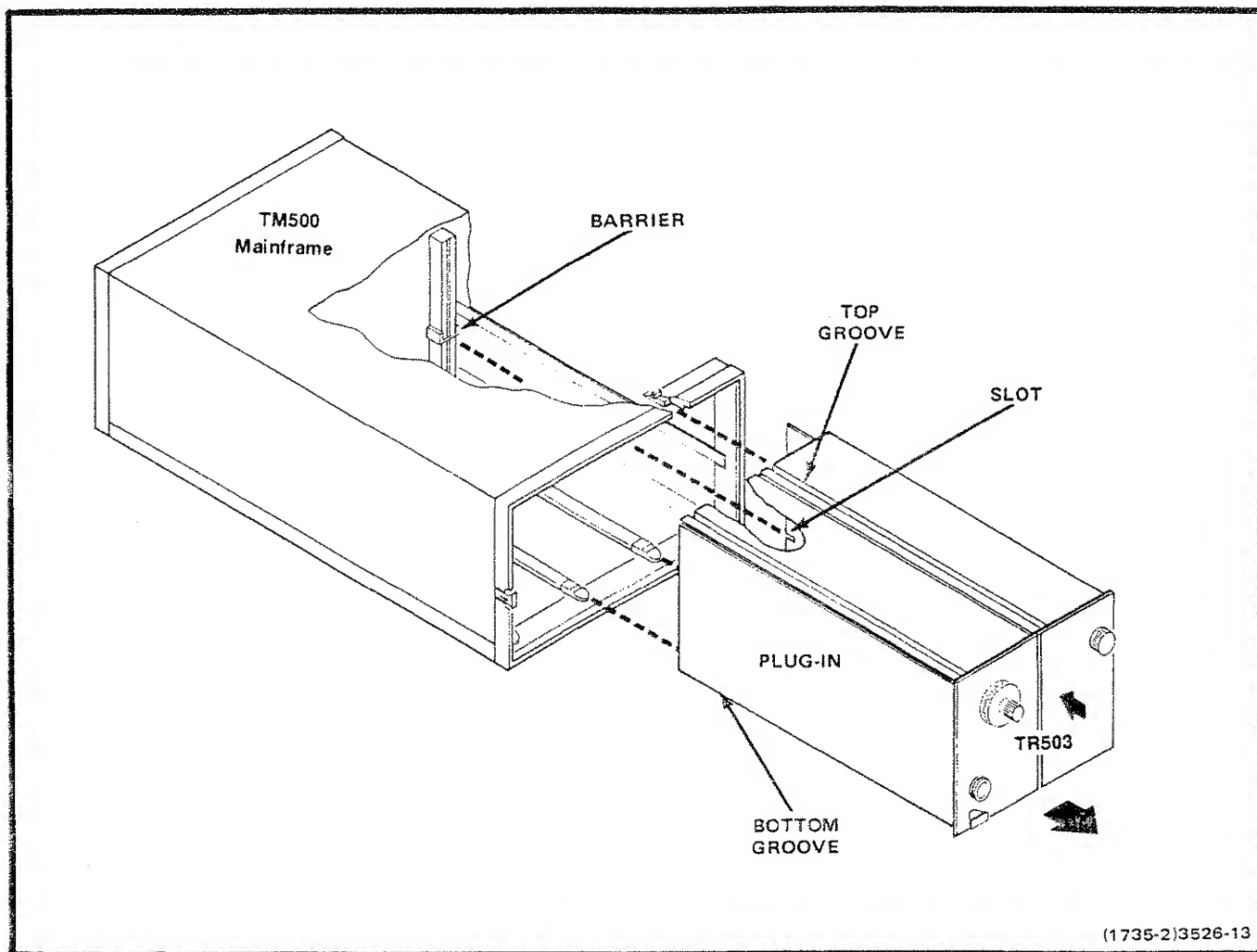
Functions of the Controls and Connectors

Front Panel Controls:

OUTPUT LEVEL: Selects 0 to 59 dB of attenuation in 1 dB steps. Controls the level of the RF OUTPUT but does not affect the AUX RF OUTPUT.

VAR dB: Provides a 0 to 2 dB range of attenuation that is continuously variable. Controls the level of both the RF OUTPUT and the AUX RF OUTPUT.

TRACK ADJUST: Adjusts the frequency offset between the TR 503 RF OUTPUT and the input frequency of the 492 Spectrum Analyzer.



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Fig. 2-1. Plug-in module Installation.

Output Connectors:

RF OUT. A 0 to -61 dBm RF signal source that tracks the input frequency of the spectrum analyzer. This must be terminated in 50 Ω to maintain flat response.

AUX RF OUT: A RF signal source for auxiliary equipment such as a frequency counter. This must be terminated in 50 Ω to maintain flat response.

Input Connectors:

1st LO IN: This accepts a signal from the 1st local oscillator (LO) of the 492 Spectrum Analyzer.

2nd LO IN: This accepts a signal from the 2nd local oscillator of the 492 Spectrum Analyzer.

Operators Checkout Procedure

Prepare the TR 503/492 system as follows:

- Insert the TR 503 and frequency counter into a TM 500 mainframe.
- Using the coaxial cables supplied with the standard accessories, connect the 1st LO output port of the 492 to the 1st LO IN of the TR 503. Connect the 2nd LO output port of the 492 to the 2nd LO IN of the TR 503.
- If a frequency counter such as the DC 508 is used, connect the AUX RF OUTput of the TR 503 to the 50 Ω input of the counter.
- Compare the connections with Fig. 2-2. The dotted lines are used to show the connections used in the

Frequency Measuring Procedure at the end of this section. The 492 Spectrum Analyzer is shown connected to either an antenna or a device under test.

e. Switch on power to all units. Warm up the instruments for at least a half-hour. (Procedure 4, Measuring Frequency, requires a two-hour warmup.) Set the Time/Div control on the 492 to Auto.

1. Check Flatness

a. Set the 492 Reference Level to 0 dBm, the Frequency to 100 MHz, the Span/Div to 1 MHz, and the Vertical Display to 2 dB/Div.

b. Adjust the TR 503 OUTPUT LEVEL and VAR dB controls so the 492 display lies on the -4 dBm line (2 divisions below the top of the screen).

c. Increase the 492 Span/Div to Max. Confirm that the response of the TR 503/492 system is within ± 2.25 dB about the midpoint (mean) between the two extremes over the 100 kHz to 1.8 GHz span.

d. Reset the 492 Vertical Display to 10 dB/Div.

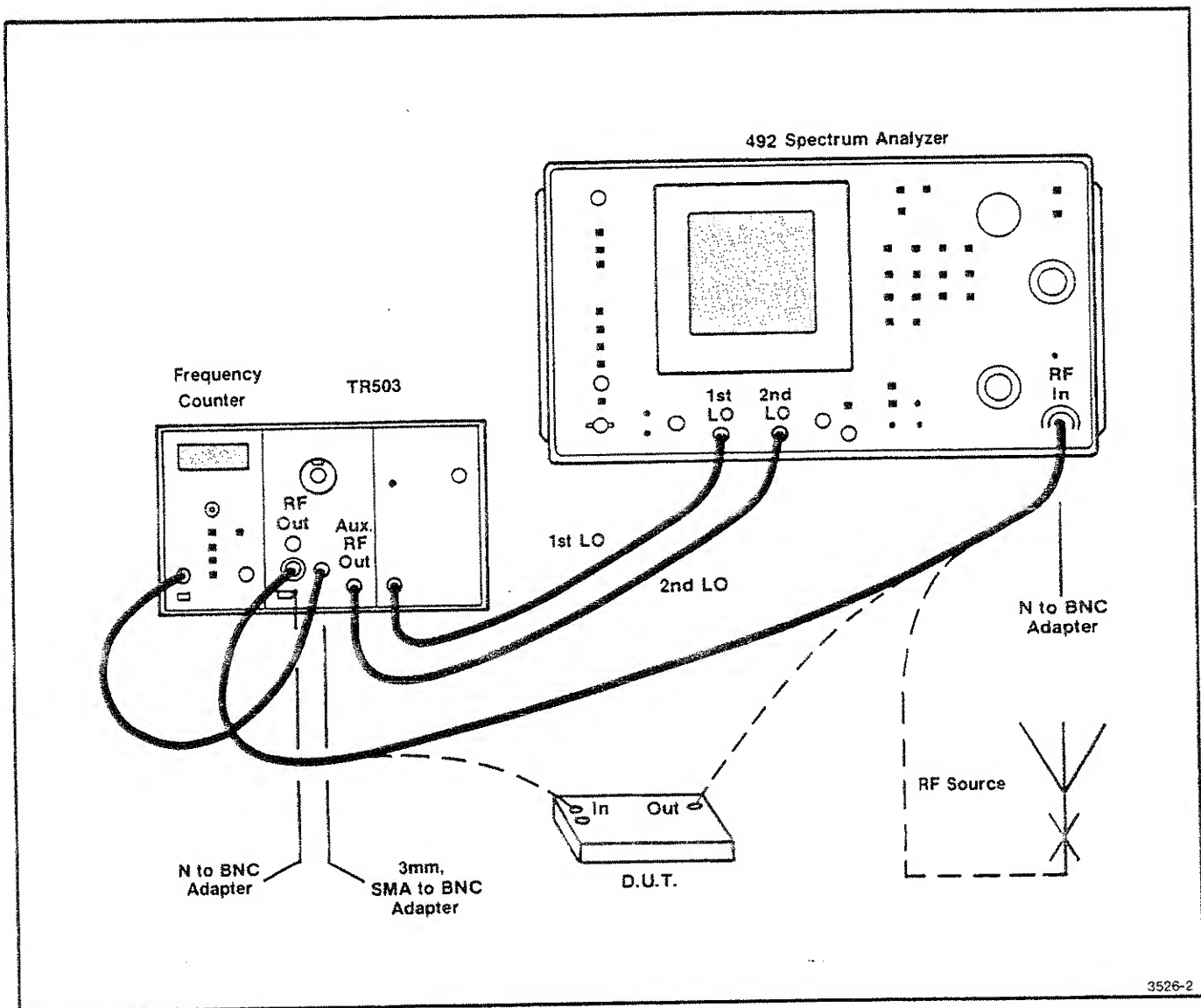


Fig. 2-2. TR 503/492 System with Frequency Counter.

2. Check Output Level

a. Set the TR 503 OUTPUT LEVEL and VAR dB to 0 dBm (VAR dB is fully clockwise).

b. Decrease the OUTPUT LEVEL to -50 dBm in -10 dB increments while decreasing the 492 Reference Level in equal increments. Check that the display level remains constant.

c. Return the OUTPUT LEVEL to 0 dBm.

d. Set the 492 Reference Level to 0 dBm, the Span/Div to 1 MHz, and the Vertical Display to 2 dB/Div. Set the 492 display on a horizontal line by slowly adjusting the TR 503 VAR dB control.

e. Decrease the TR 503 OUTPUT LEVEL in 1 dB steps and check that the 492 display decreases accordingly.

f. Return the TR 503 OUTPUT LEVEL and VAR dB controls to 0 dBm.

g. Rotate the VAR dB control through its range and check that the display on the 492 decreases in accordance with the calibrations on the VAR dB scale.

3. Tracking Adjustment

This procedure adjusts the TR 503 output frequency to match the input frequency of the 492 Spectrum Analyzer.

a. Set the 492 Reference Level to -20 dBm and the Frequency to 100 MHz. Set the Vertical Display to 2 dB/Div.

b. Set the TR 503 VAR dB to 0 (fully clockwise) and the OUTPUT LEVEL to -20 dBm.

c. Decrease the Span of the 492 until it is zero; the upper right corner of the crt will read 10 MS/. Slowly decrease the Resolution Bandwidth (the outer knob of Span/Div) while adjusting the TR 503 TRACKING ADJUST for maximum trace height. When the 492 Resolution Bandwidth is at the 100 Hz minimum setting (1 kHz in non-phaselock 492s), make a final correction to the TRACKING ADJUST. Maximum trace amplitude on the 492 screen indicates that the TR 503 and the 492 are matched.

d. The TRACKING ADJUST is now set for the 492 in the test set-up. If a different 492 is substituted, the TRACKING ADJUST will have to be reset.

e. On the 492, press Auto Resolution and rotate Span/Div clockwise into the MHz range. Set the Reference Level to 0 dBm. Set the TR 503 OUTPUT LEVEL to 0 dB.

4. Measuring Frequency

A 492 Spectrum Analyzer with digital storage (option 2) is recommended for this procedure. Referring to Fig. 2-2, connect and operate the system as follows:

a. To measure the frequency response of a device under test (DUT), close the circuit between the spectrum analyzer and the tracking generator by connecting the DUT between the 492 RF Input and the TR 503 RF OUTPUT. The DUT must have 50 Ω terminations on both input and output for this measurement to be valid.

To measure frequencies in an RF spectrum, connect the 492 RF Input to the RF source. Disconnect the 50 Ω cable from the TR 503 AUX RF OUTPUT to prevent stray radiation from this cable affecting the accuracy of the measurement. (The cable is reconnected after the desired spectra is stored in the digital memory of the 492.)

b. Adjust the 492 Reference Level, Frequency, and Span/Div to display the frequencies of interest on the crt. Deactivate View B, leaving only View A lit.

c. Press Degauss on the 492 and recenter the display with the Frequency control.

d. When the desired spectra is present on the 492 crt, press Single Sweep, Save A, and Readout. Switch the Time/Div control to MNL (one click counterclockwise). If the 50 Ω cable from the TR 503 AUX RF OUTPUT is disconnected, reconnect it before the next step.

e. The 492 Peak/Average knob now controls the vertical movement of the cursor line and while the Manual Scan knob controls the horizontal movement of the bright spot. Place this spot on the frequency of interest and read the value from the frequency counter.

f. Repeat step "e" for other frequencies on the crt display. The measurement error of this procedure is directly related to the frequency drift of the 492 between steps "d" and "e". The accuracy is improved if measurement times are kept short.

g. When finished, restore the TR 503 and the 492 to previous settings. For the 492, return Time/Div to Auto (one click counterclockwise), and press Free Run, Save A, View B, and Readout. Move the cursor to either the top or bottom of the screen, depending on choice of average or peak detection.

THEORY OF OPERATION

This section describes the functions of the major circuits and their relationships to each other. The descriptions are intended for the knowledgeable user and for the technician servicing the instrument.

The section begins with the general description, followed by the block diagram description, and ending with a detailed analysis of the major circuits. Voltage data, signal levels, and frequencies are provided in the diagrams to clarify understanding of circuit functions.

GENERAL DESCRIPTION

This subsection begins with a quick review of the signal flow through a 492 Spectrum Analyzer. The next two paragraphs "freeze" the swept output of the TR 503 at 500 MHz and describe the signals appearing at the major points of the TR 503/392 system. The last paragraph discusses details not immediately apparent from the preceding discussion. This subsection is intended to be used with Fig. 3-1, the System Diagram.

The 492 Spectrum Analyzer mixes the input signal with the 1st LO (local oscillator) frequency, obtaining a 1st IF (intermediate frequency) of 2.072 GHz. This IF is then mixed with the 2nd LO, obtaining a 2nd IF at 110 MHz. This product is then mixed with the 100 MHz 3rd LO, obtaining a final IF at 10 MHz. This signal is passed through a VR (variable resolution) stage, a log amplifier, and a peak/average detector. The detector output is either digitized and stored or sent directly to the video amplifier of the crt.

The following signals are found within the 492 Spectrum Analyzer when 500 MHz is applied to the input. The 2.572 GHz signal of the 1st LO is mixed with the input, obtaining a 1st IF of 2.072 GHz. This IF is then mixed with a 2.182 GHz signal from the 2nd LO, obtaining a 2nd IF at 110 MHz. This IF is sent to the remaining stages of the 492 (described above).

The following signals are found within the TR 503 Tracking Generator when it produces a 500 MHz output. The TR 503 accepts the 2.182 GHz 2nd LO signal and generates a phase-locked signal 110 MHz lower—at 2.072 GHz. This signal is then mixed with the 1st LO signal of 2.572 GHz, obtaining an 500 MHz output. This signal is levelled and sent to the RF OUTput, the DUT (device under test), and the 492 Spectrum Analyzer.

In practice, the TR 503 RF OUTput is a swept, rather than fixed, frequency. In addition, when the 492 is set to spans of 100 kHz/Div or more, the 1st LO is controlled by the Frequency and Span voltages while the 2nd LO is set to 2.182 GHz. When spans of 50 kHz/Div or less are chosen, the 1st LO is phase-locked (in instruments that have this option) and the 2nd LO is controlled by the Frequency and Span voltages. When the 2nd LO exceeds its tune range, the 1st LO is re-locked to a different frequency, permitting the 2nd LO to recenter its tune range.

BLOCK DIAGRAM DESCRIPTION

The 2.072 GHz oscillator is phase-locked 110 MHz below the 2nd LO frequency. The 110 MHz difference is maintained by dividing it down to 55 MHz and comparing it to a 55 MHz crystal-controlled oscillator. A voltage that is proportional to the phase difference is fed back as an error signal to the 2.072 GHz oscillator, keeping it locked 110 MHz below the 2nd LO input signal.

The 2.072 GHz signal is passed through a directional coupler which couples some of the signal to the phase-locked loop and directs the remaining energy through a leveling attenuator (setting the desired amplitude), a 2.2 GHz low-pass filter (attenuating harmonics and upper sidebands from the output mixer), a second leveling attenuator, an isolation amplifier, and a 6 dB attenuator feeding into the output mixer. The isolation amplifier assists the low-pass filter in preventing energy from the output mixer from leaking into the 2.072 GHz oscillator and the phase-locked mixer circuit.

At spectrum analyzer frequencies near zero, the 1st LO is near 2.072 GHz. This frequency will disable the phase-lock if leakage from the output mixer is present. The 6 dB attenuator serves to smooth the output impedance of the isolation amplifier, improving the load seen by the output mixer.

The conversion loss through the output mixer is essentially constant with frequency. The amplitude level of the IF signal tracks the amplitude level of the rf signal with 6 to 8 dB of loss. The IF level is set by controlling the rf level input level. A constant output level is maintained by a feedback loop that controls the attenuation of the 2.072 GHz signal path. The forward signal path through the attenuator affects the amplitude at the level detector. The feedback path applies this amplitude to the leveling attenuator as a correction signal so the output remains constant over the frequency range of the TR 503.

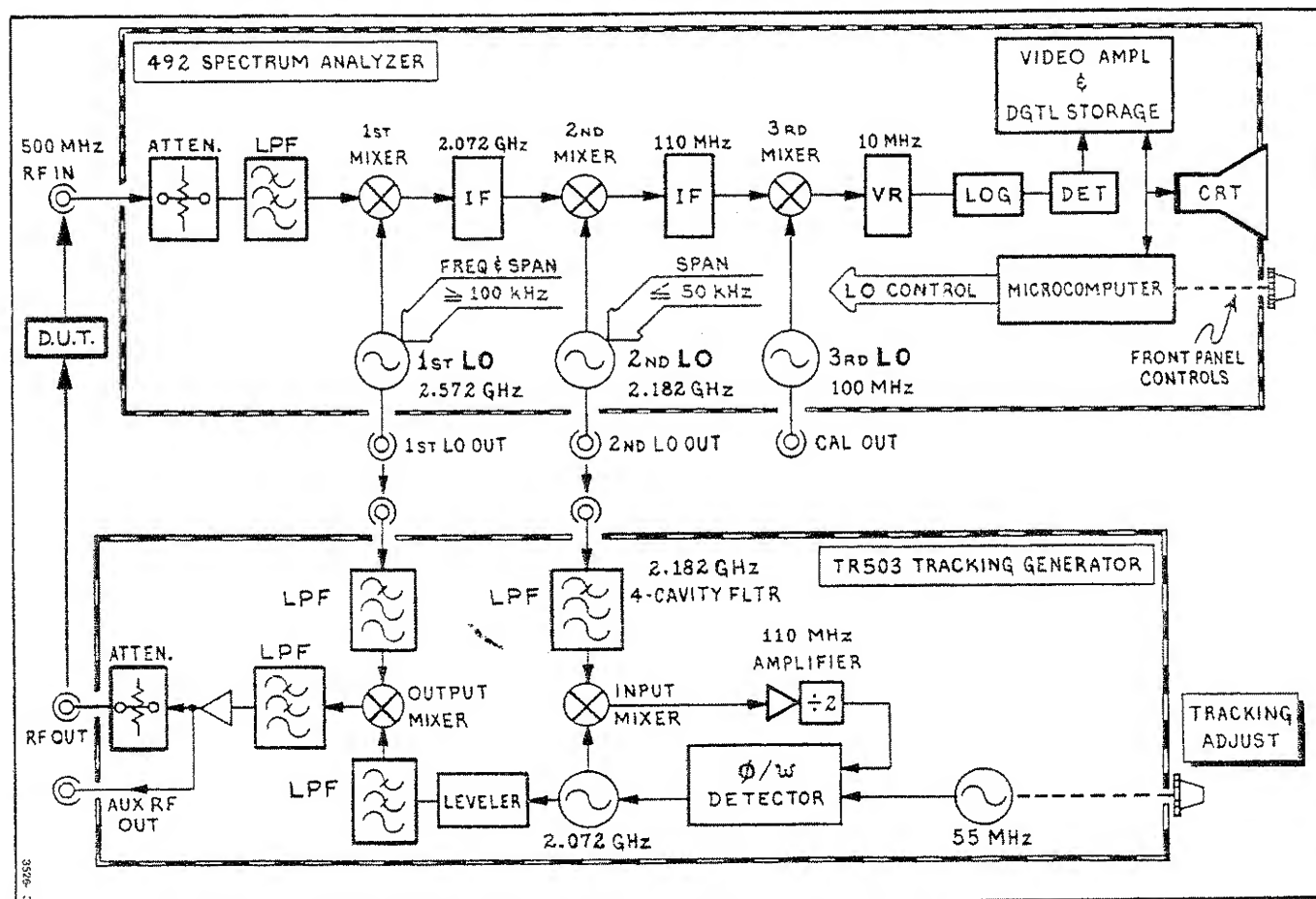


Fig. 3-1. TR 503/492 System Diagram.

The input signal from the 1st LO is 4 dBm or more. This is amplified by the 2.1 GHz to 3.9 GHz amplifier so the level into the LO port of the output mixer is between 7 dBm and 10 dBm. Harmonics of the input signal are attenuated by the 2.1 GHz to 3.9 GHz bandpass filter. Re-entrant modes of this filter are eliminated by a low-pass filter. Two ferrite isolators provide correct termination for the

amplifier and bandpass filter. These isolators and the amplifier prevent interaction between the output mixer and the 1st LO. This isolation and a filter prevent signals in the 0 to 1.8 GHz and 4.2 to 6 GHz range from entering the spectrum analyzer. Leakage from these signals would degrade the sensitivity of the analyzer and lift the display baseline.

DETAILED DESCRIPTION

RF and Microwave Circuits

The RF section consists of microwave assemblies that include microwave integrated circuits in metal enclosures. Because repair of these assemblies requires special techniques and equipment we recommend replacing the entire assembly if failure should occur. The diagrams for these assemblies show only basic configurations and illustrate functions and dc paths between external connectors.

The input signal from the spectrum analyzer is amplified to a level of 10 mW by the 2.1 GHz to 3.9 GHz amplifier. The nominal gain of the amplifier is 6 dB. Because of gain characteristics, this amplifier operates as a limiter and provides a relatively constant output over a wide range of signal levels. This limiting action provides a constant LO signal level to the output mixer.

The 2 to 4 GHz isolators have less than 0.4 dB loss in the forward direction and more than 20 dB loss in the reverse direction. The 4.5 GHz tubular low-pass filter attenuates the re-entrant mode of the interdigitated bandpass filter (at the third multiple of its passband). This bandpass filter attenuates harmonics of the 2.1 to 3.9 GHz signals that are generated by the spectrum analyzer and the saturated 2.1 to 3.9 GHz amplifier. This filter also attenuates 0 to 1.8 GHz and 4.2 to 6 GHz signals that return from the output mixer of the TR 503.

The mixer requires about 5 mW into the LO port and a nominal -24 dBm into the rf port. The IF output of the mixer is about -30 dBm over the frequency range of 0 to 1.8 GHz.

The 2nd LO signal from the spectrum analyzer is applied through a 20 dB attenuator, a 2.2 GHz low-pass filter, and a four-cavity bandpass filter to the mixer. The 2.2 GHz low-pass filter attenuates or blocks re-entrant modes (at 6.546 and 10.91 GHz) from the four-cavity bandpass filter. The passband of this filter is narrow enough to attenuate the 2.072 GHz oscillator signal, preventing this signal from entering the spectrum analyzer. Four tuning screws, one for each cavity, serve to adjust the response of the bandpass filter. The signal then passes through a two-diode balanced mixer, where it is mixed with the signal from the 2.072 GHz oscillator. The position of the mixer affects the response of the filter by controlling mixer balance and coupling.

The 110 MHz IF signal from the mixer is passed through a directional coupler and an all-pass network to the 110 MHz amplifier. The all-pass network provides correct termination for the directional filter.

The 2.072 GHz oscillator sets the frequency by coupling a resonant micro-strip transmission line to the collector of the common-base oscillator. 20 MHz of tuning is available by varying the collector voltage, which in turn alters the collector-base capacitance of the oscillator transistor.

The 2.072 GHz signal is fed from the directional coupler to a PIN diode attenuator with the diode operating as a variable resistor. The circuit is a "T" attenuator with the resistance of the diode inversely proportional to the current. As the current increases (from 0 to 5 mA) the resistance changes from open-circuit to 5 Ω . This variable allows initial adjustment of operating range.

The 2.2 GHz low-pass filter attenuates harmonics of the 2.072 GHz signal in the forward direction as well as higher frequencies that leak through the isolation amplifier from the output mixer.

The leveling attenuator and normalizing attenuator are identical. The forward gain of the isolation amplifier is 7 dB; the reverse gain is -20 dB or less. This amplifier drives the mixer through a 5 dB attenuator.

The lower conversion frequencies from the mixer pass through a 3 dB attenuator and a low-pass filter to the wideband amplifier. The 3 dB attenuator provides a wideband (to 6.6 GHz) termination for the mixer and the low-pass filter attenuates 2.072 GHz and higher products from mixer. This filter is flat up to 1.8 GHz and cuts off above that with a sharp notch at 2.072 GHz. The wideband amplifier provides 40 dB of gain.

The wideband amplifier sends its output to a second 1.8 GHz low-pass filter. This filter rejects harmonic distortion products of the amplifier. (Amplifier distortion is dependent on signal frequency and level.) The filter output is sent to the power divider and peak detector.

The level detector is a directional peak detector that senses forward power but not reflected or reverse power. The forward power is load-independent. The power loss through the divider is 6 dB for the RF OUT connector and 9.5 dB for the AUX RF OUT connector. The output attenuator provides calibrated 1 dB and 10 dB steps of attenuation for the RF OUT connector.

Bias and Leveling Loop Circuitry

Bias for the microwave and isolation amplifiers is supplied by five bias supplies (U150, U160, U170, U180, and U240) on the Bias circuit board. The bias circuits and rf amplifiers are connected by a feedback loop with the collector load current of the rf amplifier sensed by the input resistor (R) of the operational amplifier. The voltage

across this resistor is compared to a +10 V reference. The op amp output drives the base of the rf amplifier, setting the bias and holding the collector resistor voltage at +10 V.

The load resistors for the output amplifiers are R140, R162, R174, and the resistor in the microwave assembly for the final amplifier stage. These resistors set the collector currents of the first two amplifiers at 10 mA, the third amplifier at 20 mA, and the final at 30 mA. The load resistor (R242) for the isolation amplifier sets the collector current at 15 mA.

The +10 V reference for the bias circuits is generated by a voltage regulator circuit using op-amp U250. The reference for the regulator is a 6.2 V Zener diode (VR258) which sets the voltage level at the inverting input of the op amp. This is amplified to +10 V. The bias current for the 6.2 V Zener is provided by the +10 V reference. A 7.5 V Zener (VR250) is connected from the output to the +15 V supply; the Zener is used to start the +10 V reference. As soon as the output of the regulator exceeds +7.5 V the Zener ceases to draw current and is isolated from regulator operation.

Diode CR250, connected between ground and the +15 V line, protects the microwave circuitry from accidental application of negative voltage.

The leveling loop consists of a level detector and a temperature-compensating diode driving a differential amplifier. The output of this amplifier drives a second amplifier which sets the leveling attenuator. With no power into the detector, the output of the diodes is close to 0.4 V. The diode outputs drive the inputs of differential amplifier U200. The output of the compensation diode is summed with a voltage set by the leveling control circuit. The temperature compensating diode corrects for detector output variations induced by temperature shifts. As power into the detector increases, positive signal excursions are clamped to +0.4 V.

U200 is an op-amp configured as an integrator. Its output is a correction signal depending on the difference between the reference and level detector. The reference voltage is set by a voltage divider network composed by R225, R220, R222, and the front panel VAR dB control. Min Output Level adjustment R225 sets the minimum level (or offset constant). Max Output Level adjustment R220 sets the range of the VAR dB control to cover 2 dB. The VAR dB Linearity adjustment shapes the output level to maintain calibration of the VAR dB control. The reference for the output level control circuitry is set by a 6.2 V Zener diode (CR262).

Phase Lock Loop

The 2.072 GHz oscillator is phase locked 110 MHz below the 2.182 GHz 2nd LO signal from the spectrum analyzer. The 110 MHz difference product from the input mixer is sent through five stages of amplification, divided down to 55 MHz, and compared to a 55 MHz signal from the crystal oscillator. A voltage that is proportional to the phase difference between the two 55 MHz signals is fed back to the 2.072 GHz oscillator, forcing its output to be exactly 110 MHz below the 2.182 GHz 2nd LO signal.

The 110 MHz signal is sent through three stages of common-emitter amplification, transistors Q550, Q505, and Q510. The collector of Q510 is coupled to transformer T520, which provides a differential signal for the next two stages. Differential amplifiers U540B and U540A successively amplify the 110 MHz signal and send it to a divide-by-two counter, U550. The total gain is about 60 dB for an input below -45 dBm; from -45 dBm to +10 dBm the output remains relatively constant. U550 provides a 55 MHz output which is sent to the phase/frequency detector U545. This device compares the signal from U550 to the signal from the 55 MHz crystal-controlled oscillator.

The reference 55 MHz signal from the crystal-controlled oscillator U520A is sent through buffer U520B which is connected to the phase/frequency detector U545. The crystal operates on the third overtone which is selected by the low Q resonant circuit tuned by C524. The frequency can be tuned through 55 MHz by varying the voltage bias on the variable capacitance diode CR526. This bias is set by the front panel TRACKING ADJUST control R10. (Voltages for the adjustment are supplied by U365B). This control allows the operator to set the TR 503 to the spectrum analyzer input frequency or offset the frequency by a slight amount.

The output of the phase/frequency detector is sent to a compensating amplifier U365A and Q420. The compensating amplifier has a buffered output that drives the collector of the 2.072 GHz oscillator. Q440 limits the current if the output is inadvertently shorted.

Transistors Q445 and Q430 are the active components of an anti-latch circuit. When this circuit is activated, it drives the 2.072 GHz oscillator through a frequency band until it locks to the 2nd LO of the spectrum analyzer. When the tune voltage is +3 V or less, Q445 is cut off. The collector voltage rises towards Vcc and allows C432 to charge through R438 and R444 until it is 0.7 V above the gate potential of Q430 (this is a programmable unijunction transistor). When this transistor turns on, the charge on the capacitor C432 is transferred to the cathode and sent to the non-inverting input of operational amplifier U365A (C428 also acquires a charge). The output of the compensating amplifiers steps positive to about +18 V, then decays linearly towards 0 V. As the tune voltage passes through a range that will lock the 2.072 GHz oscillator to

the 2nd LO of the spectrum analyzer, the phase lock regains control. If the oscillator fails to start or lock, the cycle is repeated.

Q410 is the 25 mA current source for the 2.072 GHz oscillator. Q480 is the output of the +20-V supply for the compensation amplifier circuitry.

Power Supply Regulators

Three power supply regulators (U350, U370, and U390) provide +15 V, -15.1 V, and -15 V respectively. These IC regulators use external pass transistors that are located in the TM 500 mainframe for the positive supplies and on the Mother board of the TR 503 for the negative supply. All

regulators are short-circuit protected with foldback current limiting.

For example: the -15 V supply (U390) current sensing resistor is R394 and the foldback circuit includes R398 and R396. If the current delivered to the load becomes excessive, the voltage drop across R394 will be enough to turn on the current-limiting transistor Q395. This decreases the current through the pass transistor Q390 and limits the current to the load. Foldback current is 50 mA ($1 \text{ V}/20 \Omega$) and power dissipation in the pass transistor is about 1 W ($50 \text{ mA} \times 20 \text{ V}$). If the -15 V line is shorted to ground, the current will be limited to 35 mA ($0.7 \text{ V}/20 \Omega$) and the power dissipation to 1.2 W ($35 \text{ mA} \times 35 \text{ V}$).

Instrument Serial Numbers

Each instrument manufactured by Tektronix has a serial number on a panel insert or tag, or stamped on the chassis. The first letter in the serial number designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

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